A Hybrid Immersive / Non-Immersive Virtual Environment Workstation

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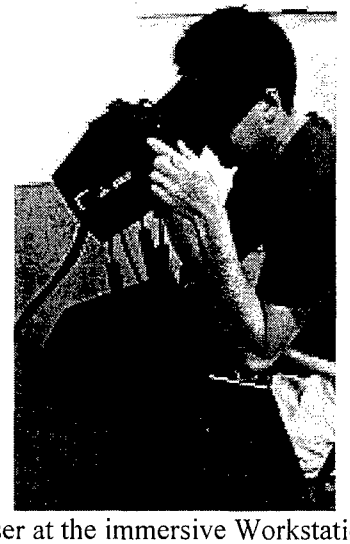
Introduction

In the course of this research project we have been exploring the integration of Immersive and Non-Immersive systems. This development and research has lead to a number of innovative ideas and system configurations. In particular, we have developed prototypes which make models shown on the Non-Immersive system appear more real; pushed the development of alternative input devices for interaction with three dimensional models; and gained more insight into the nature of presence. In addition to prototype hardware and software systems, our research has also lead to a potentially new method for supporting several users around a Non-Immersive virtual workbench type display. The capability to support several users clustered around the Non-Immersive system will permit very powerful future applications. One can envisage several users around the Non-Immersive system evaluating a particular situation. They can then dispatch particular areas or features for evaluation in detail by other users who are looking at the same database with the Immersive workstation. This type of hybrid cooperative application is very promising and could be performed at a single site or over a network consisting of several sites.

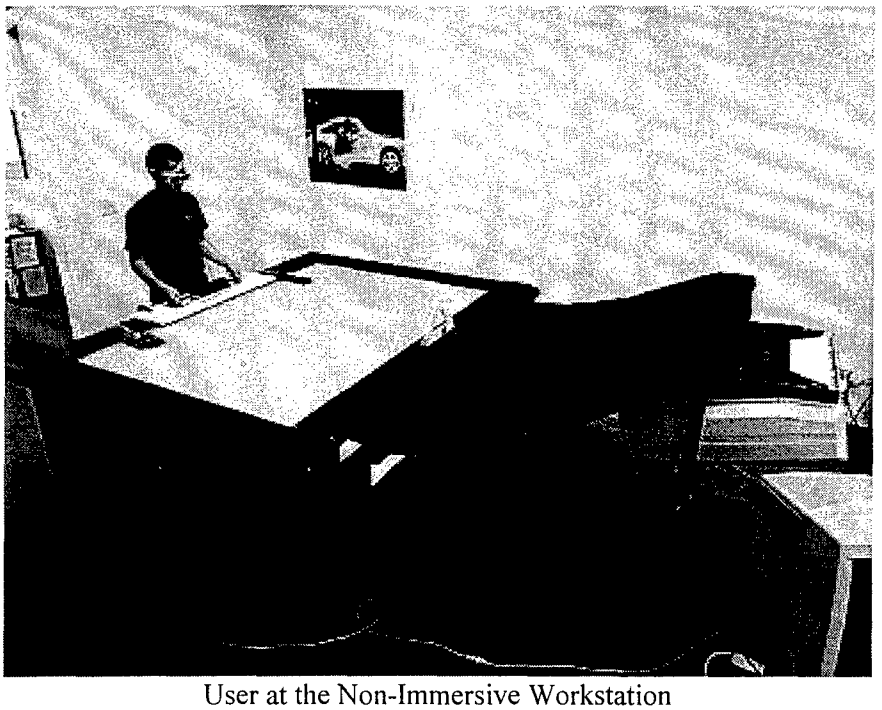
The basic system configuration for the Immersive Workstation includes a high resolution stereoscopic display on a compliant base. The compliant base implements a unique navigational paradigm which uses the body's axial muscles to facilitate navigation in the virtual space. This navigational interface permits the user to control their position with ease, at both a macro and a micro scale without changing modes. The Immersive Workstation provides the user with an immersive experience and does not require any head gear to be worn. One can easily sit down and use the station without having to make any significant adjustments.



User at the immersive Workstation

The Non-Immersive Workstation user also sees high resolution stereoscopic images but in a very different way. The Non-immersive system is based on a large rear projection table type display. The user views the stereo images on the display surface and navigates using the same navigational paradigm as the Immersive user. The actual input device which implements the interface is different. Several people could stand around the display to point and discuss the virtual model projected onto the table surface. Using currently available technology, two interactive correct stereo perspective views can be supported. In the course of our research, we

have found a method for extending this to a larger number of simultaneous viewers. This future system would also have the potential to be self contained, rugged, and deployable in a shipboard environment.



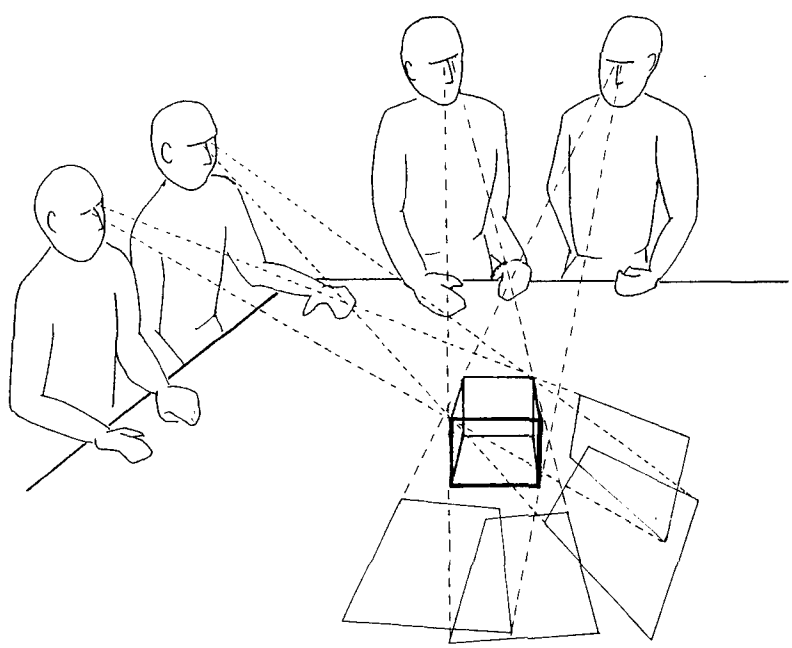
User at the Non-Immersive Workstation

Both the Non-Immersive and Immersive workstations are driven by a single Silicon Graphics Machine (Crimson RE with Multi-Channel Option). The Multi-Channel Option (MCO) simultaneously drives both the Non-Immersive and the Immersive displays in stereo. All the trackers and other input devices are connected to the serial ports of the machine. The prototype software developed and used in the research we performed is written in C using the SGI Performer Libraries. While the current software implementation is merely a prototype, it would be possible to extend the software to permit the various users of the Immersive and Non-Immersive workstations to be on different machines. By using a standard networked architecture, the graphics performance of the various stations could be improved because each user could have a dedicated machine, rather than relying on a central resource.

Key Developments

Powerful Simultaneous Multi-User Capability

The Non-Immersive display can be expected to be used by several people simultaneously. This therefore requires that several head-tracked stereoscopic views be presented on the display surface simultaneously. Fakespace has developed a system for two simultaneous users based on CRT projectors. Building on that experience, we have developed an approach for using an alternative projection technology which, it is expected, could support several simultaneous viewers at once. This is very exciting because the ability for people to share information is critical.



Four Users Looking at a cube
(note their radically different perspectives)

This new approach would also permit the display of different information to selected users. There are many possible scenarios which take advantage of this unique capability. For example:

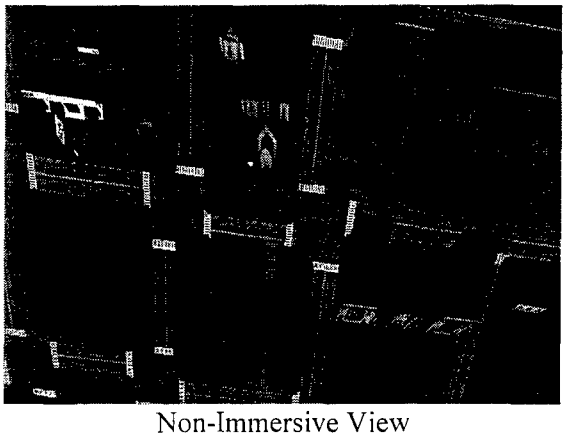
> **Several Users - Overlays:** Several people are discussing a particular area of a map and the various features of the terrain. One user might want to call up a particular satellite image of the area. The overlaid image can be made to appear in *only* that person's view. This is beneficial because while all users share a common underlying database, each user can overlay information specific to their interests and expertise. Overlays showing suspected mine fields might be very relevant to someone commanding ground forces while less important to the person coordinating air support.
>
> **User Specific Queries:** One user may wish to see information pertaining to a particular entity. They may pick the entity (either using a virtual laser pointer, or by pointing into the model with their hand). The status window then appears. That window need not impact anybody else's view of the data base.

While this new multi-person perspective system has not been proven yet, we are confident that more than two simultaneous users could be supported.

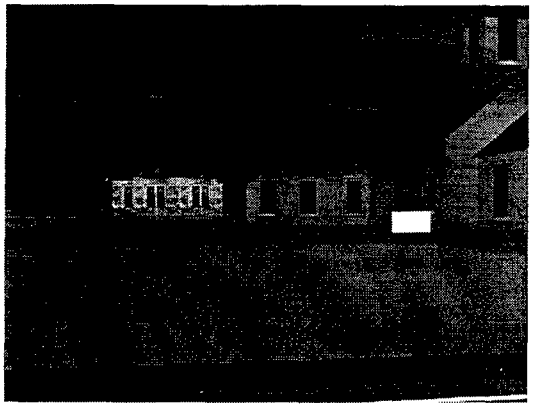
This new system would incorporate projection technologies which produce stereo images from one or two lenses. The projectors are also physically smaller therefore lending themselves to being located underneath the table. Ideally, the projectors would be located entirely beneath the table so that users may walk around the display and view it from any perspective.

Prototype Multi-User Immersive / Non-Immersive Software

The prototype software written as part of this research effort permits two users to explore the same database in two very different ways. The user at the Non-Immersive workstation sees the database from a "God's eye" perspective. The Immersive user's view is immersive in that they are in the scene. An icon can be used to show the position and orientation of the Immersive viewer to the Non-Immersive observer.



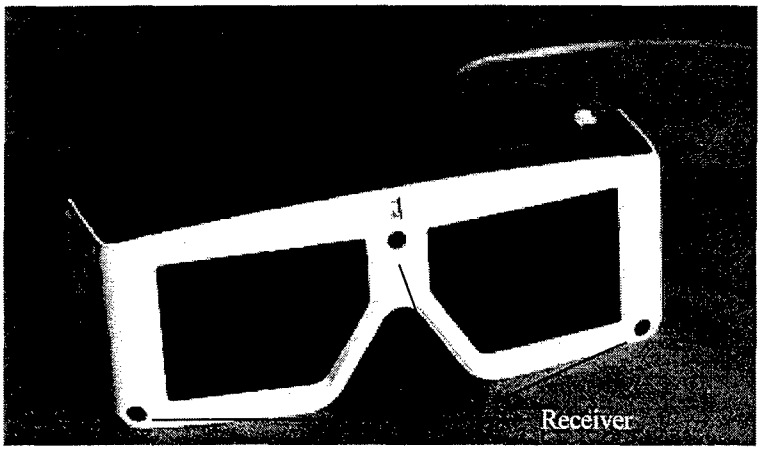
Non-Immersive View



Immersive View

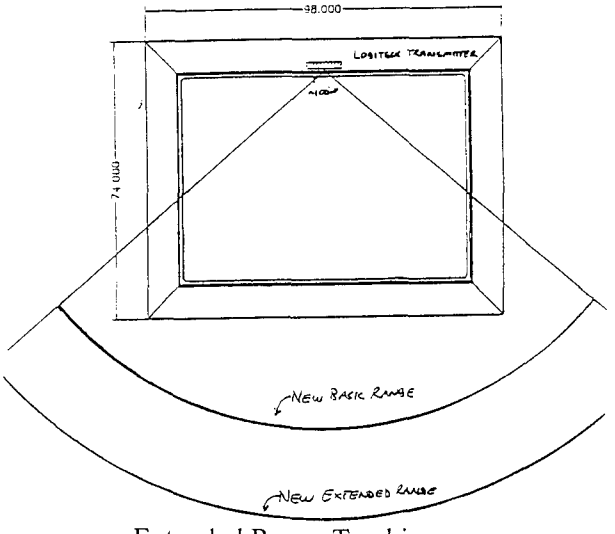
Longer Range Acoustic Tracking

Magnetic tracking systems are not well suited to ship board use because of the metallic nature of the environment. One alternative technology is ultrasonic tracking. In trying to use the Logitech 3D Mouse systems for head-tracking, the range was found to be inadequate so the firmware of the tracker was altered to increase the range. In addition to nice smooth tracking, the receiver can be integrated into the standard Stereo Graphics glasses as shown below.



Tracker in the frame of the glasses
(The three small black disks are the tracker's receiver)

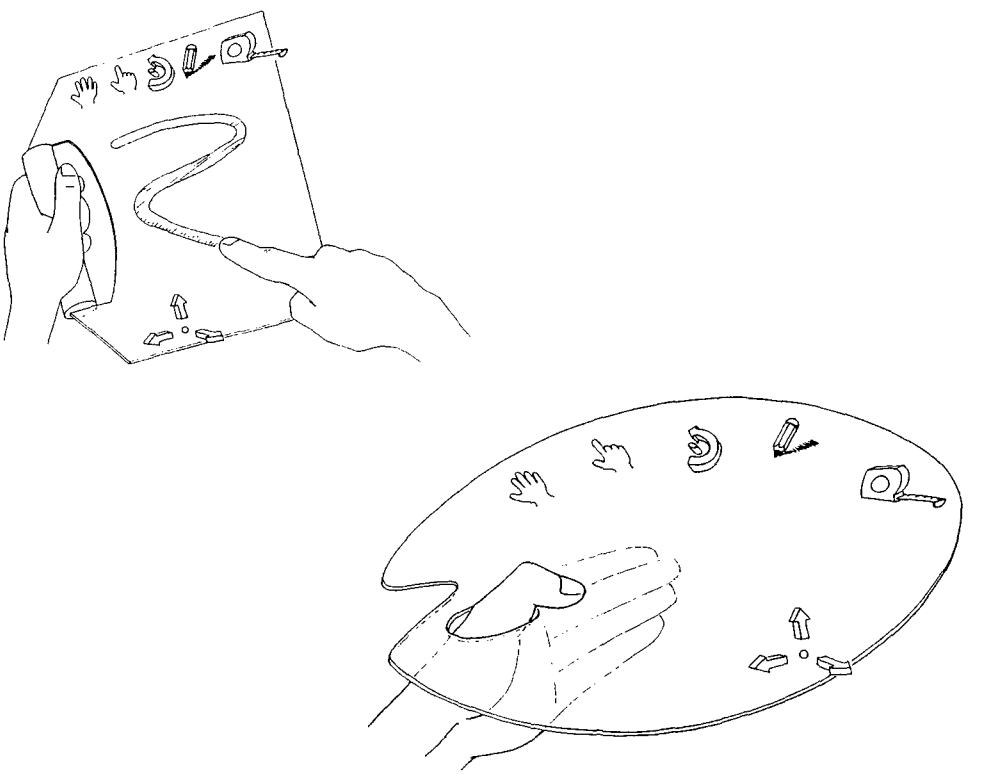
While acoustic tracking is probably not ideal for a naval environment, it could be used in conjunction with magnetic tracking to obtain the desired tracking accuracy, smoothness, and precision. In addition, we were pleasantly surprised that the line of sight nature of the acoustic tracking was not objectionable. This make us confident that an optical IR line of sight tracker would also work reasonably well and would be less sensitive to external interference than either the acoustic or magnetic tracking alternatives. Both the acoustic and potentially the IR methods can be made wireless which would be a great improvement.



Extended Range Tracking

New Interaction Devices

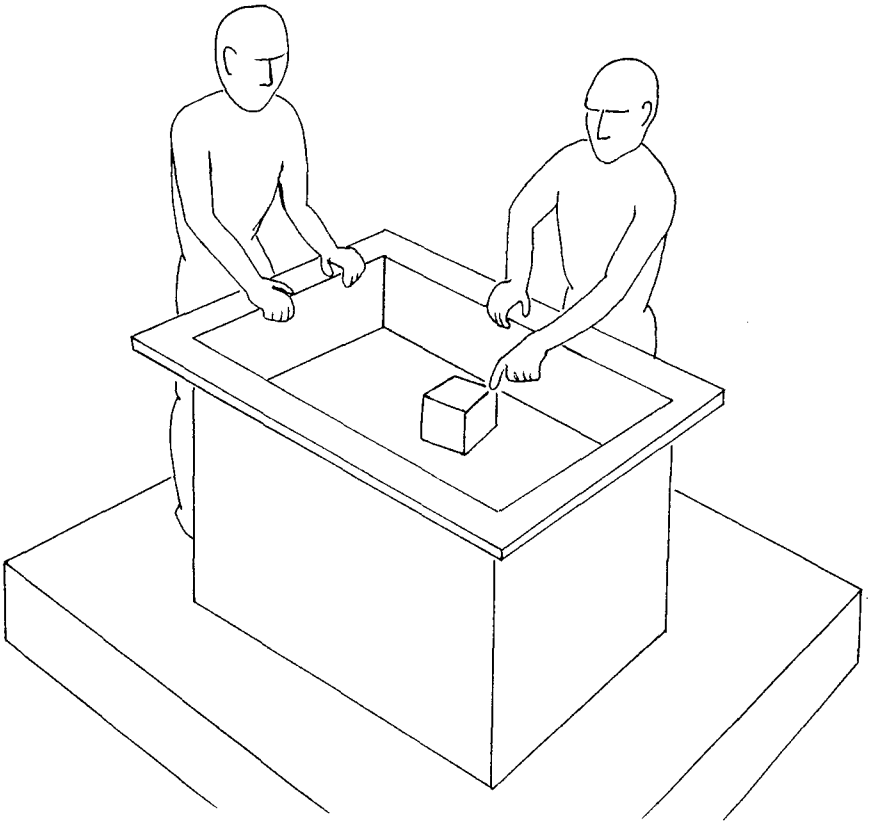
In developing the interaction paradigms for the Immersive and Non-Immersive workstation, we concentrated on the Non-Immersive user. In order to provide the Non-Immersive user with selection and interaction tools, we developed the idea of clear touch tablets (called V-palettes) which are held by the user. These tablets provide the user with menus which float in space and are activated by touching the appropriate area on the V-palette.



Renderings of several V-palettes

New Configurations for Non-Immersive Displays

In trying to achieve the most spatial images on the Non-Immersive display, we found that one technique for creating more of an impression of space was to raise the perimeter of the display area so that one can rest ones hands on the edge and reach into the three dimensional model space.



Rendering of the Raised edge

Consistent Navigational Paradigms

In developing a prototype which provides a consistent user interface to the Immersive and Non-Immersive workstations, the axial muscle based Push interface was used. This interface provides a high degree of control over many orders of magnitude without mode changes. It also provides capabilities from a navigational perspective which are particularly beneficial to the Immersive user. The desktop Push frees the immersive user to look in any direction while moving. For example, it is easy to move down a street while turning to look at the buildings to the right or left without deviation from one's desired motion down the street.

The PushStick is used by the Non-Immersive user. The PushStick implements the same type of navigational interface as the desktop Push display and is based on non-linear axial muscle control. The use of the same fundamental type of navigational paradigm leads to a consistent feel when moving from one workstation to the other.

PushStick

Desktop Push

Conclusion

In conclusion, much progress has been made towards the integration of the Non-Immersive and Immersive Workstations. In particular, we have prototyped various software and hardware components to accomplish this.

In our research on ship-compatible tracking we experimented with acoustic tracking for the Non-Immersive user and found that line of sight tracking is less problematic than one might expect on the basis of people's experiences with head mounted displays. The Immersive workstation tracking is mechanical and thus not subject to any interference from normal external sources.

The research into the presentation of imagery on the Non-Immersive display leads us to believe that for a single viewer, passive glasses could be used in conjunction with optical tracking thus totally freeing the user from wire and batteries. For the multi-person stereo system we expect that the glasses and tracking can be made wireless but not passive.

The Immersive user workstation is compact and suitable for seated use which addresses the safety issues one might come up against with traditional head mounted displays or Boom type displays used on board a ship.

The foundation developed for the future realization of a Non-Immersive head-tracked stereo system capable of supporting a number of simultaneous viewers is very promising. We believe such a system would potentially have a much smaller physical footprint than the current Non-Immersive system.

We look forward to continuing this effort and developing the multi-person capability into a tool which we believe will fundamentally change the way command and control systems function in the future. There is a wealth of computer gathered data. The timely and intelligent presentation of this data for decision makers is crucial for making the best possible decisions with confidence and speed.